DVCS predictions + fits based on H1/ZEUS + EIC mock data

Salvatore Fazio
BNL

Kresimir Kumerički
University Zagreb

Dieter Müller
BNL/Ruhr-University Bochum

KMP-K, 0807.0159 [hep-ph]; **KM 0904.0458 [hep-ph]**
flexible GPD model for small *x* and fits of H1/ZEUS data
two codes in Phyton (+ Minuit + GeParD) & Mathematica + GeParD

S. Fazio in 1108.1713 [hep-ph]
EIC mock data 20 x 250 from a modified NLO Freund/McDermott code, exponential t-dependence
statistical errors, smeared kinematical variables + 5% systematic error added by hand

Model based on SL(2,R) and SO(3) PWE

- SL(2,R) GPD moments: $F_j(\eta,t) = \sum_{J=J^{\min}}^{j+1} f_j^J(t)\,\eta^{j+1-J}\,\hat{d}_J(\eta)$

partial wave amplitudes depending on j and J

reduced Wigner rotation matrices

- taking 2 better 3 SO(3) PWs:
  (two parameters s_2 and s_4)

$$f_j^{j-1}(t) = s_2 f_j^{j+1}(t)\,,$$
$$f_j^{j-3}(t) = s_4 f_j^{j+1}(t)\,,$$

- resulting CFF easy to handle:

$$\mathcal{F} = \frac{1}{2i}\sum_{\substack{k=0\\ \text{even}}}^{4}\int_{c-i\infty}^{c+i\infty} dj\,\xi^{-j-1}\frac{2^{j+1+k}\Gamma(5/2+j+k)}{\Gamma(3/2)\Gamma(3+j+k)}\left(i-\frac{\cos(\pi j)\mp 1}{\sin(\pi j)}\right)$$
$$\times s_k E_{j+k}(\mathcal{Q}^2) f_j^{j+1}(t)\hat{d}_j(\xi),\quad s_0=1$$

- zero-skewness GPD: $h_j^{j+1} = q_j\,\frac{j+1-\alpha(0)}{j+1-\alpha(0)-\alpha' t}\left(1-\frac{t}{M_j^2}\right)^{-p}$

PDF

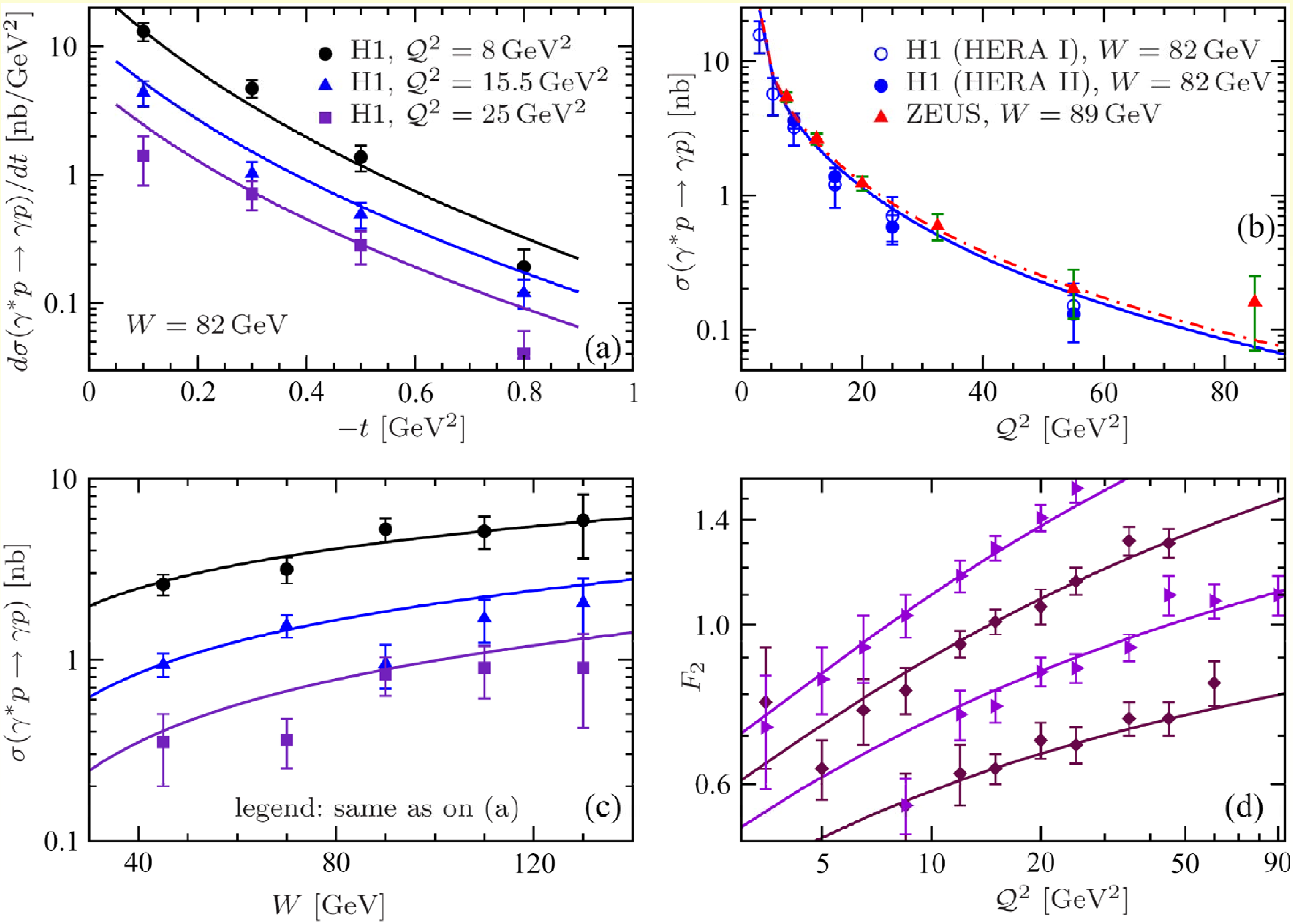
\`pomeron intercept' (biuld in PDF) + Regge slope

residual t dependence

2x(2, 3, or 4) parameters:

***s_2, s_4, M or b*, (perhaps α')**

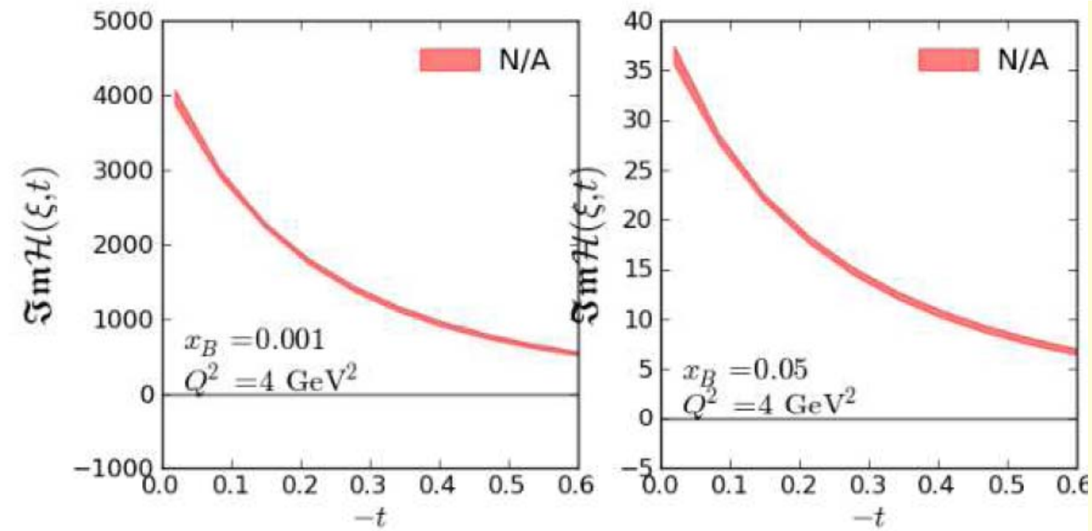
good DVCS fits at LO, NLO, and NNLO with flexible GPD ansatz



H1/ZEUS data

~ 180 data points H1/ZEUS, not statistically independent

four parameter H1/ZEUS fit (s_2^Q, M_2^Q, s_2^G, M_2^G) provides small error bands



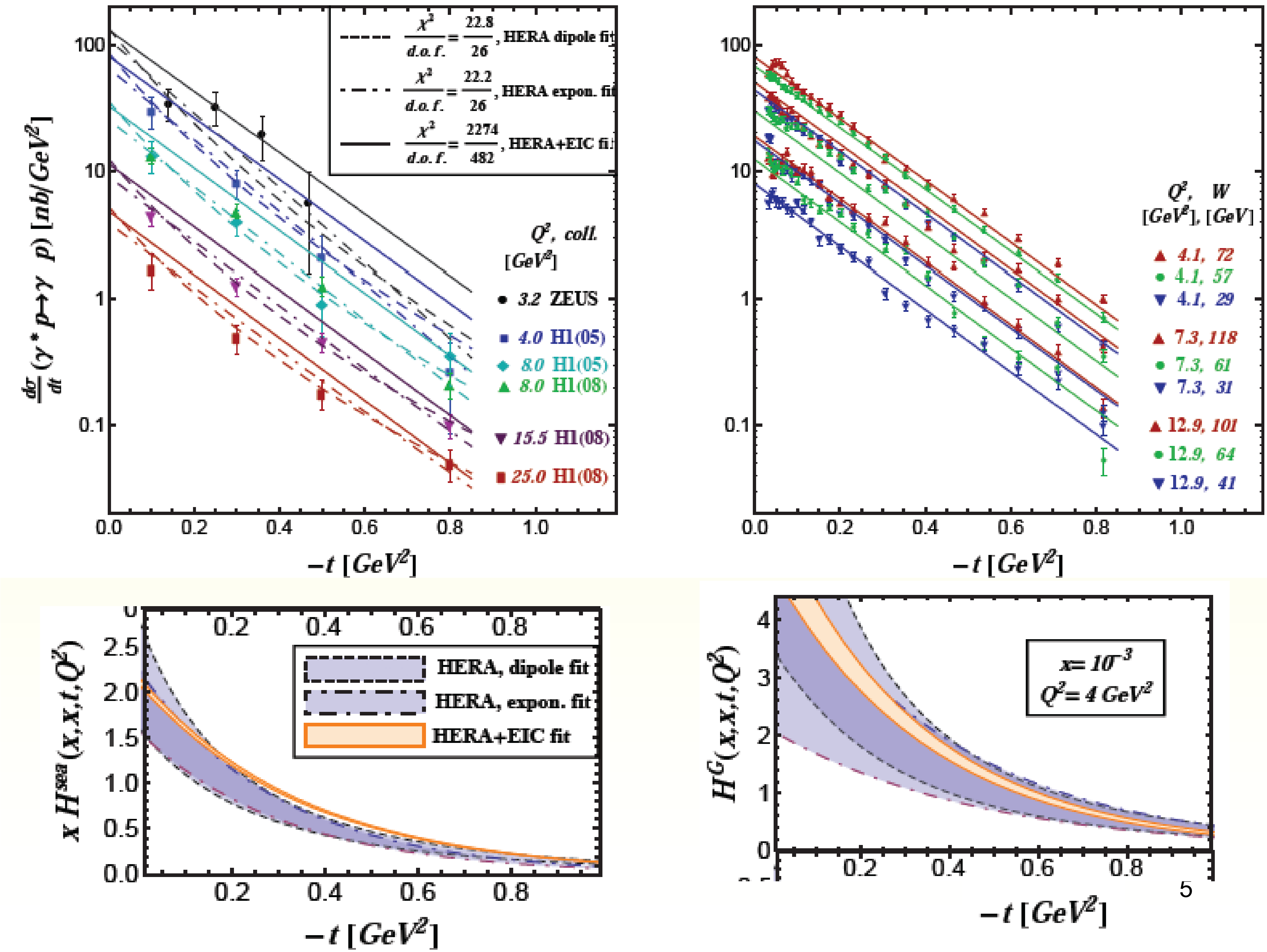
Note: PDF is considered as known (another uncertainty)
(n^{sea},α^{sea}, α^{sea}, are fixed and $n^{sea}+n^{val}+n^{G}=1$)

art of error propagation

increasing amount of (compatible) data will reduce error bands
increasing parameter set might result in bigger error bands
taking strongly correlated parameters s^2,s^4 might induce very big error bands
error bands depend on model assumptions and hypotheses

4 parameter fit with fixed PDFs

~ 30-50 H1/ZEUS points might be considered as independent
b=5/GeV^2 is a bit incompatible with H1/ZEUS data
new mock data from Salvatore with b ~ 5.6/GeV^2 are better
(not entirely consistent with HERA data, statistically inconsistent)



$\frac{\chi^2}{d.o.f.} = \frac{22.8}{26}$, HERA dipole fit
$\frac{\chi^2}{d.o.f.} = \frac{22.2}{26}$, HERA expon. fit
$\frac{\chi^2}{d.o.f.} = \frac{2274}{482}$, HERA+EIC fit
$\frac{d\sigma}{dt}(\gamma^* p \to \gamma\ p)$ [nb/GeV^2]
Q^2, coll. [GeV^2]
3.2 ZEUS
4.0 H1(05)
8.0 H1(05)
8.0 H1(08)
15.5 H1(08)
25.0 H1(08)
$-t$ [GeV^2]
Q^2, W [GeV^2], [GeV]
4.1, 72
4.1, 57
4.1, 29
7.3, 118
7.3, 61
7.3, 31
12.9, 101
12.9, 64
12.9, 41
$-t$ [GeV^2]
$x\,H^{sea}(x,x,t,Q^2)$
HERA, dipole fit
HERA, expon. fit
HERA+EIC fit
$-t$ [GeV^2]
$H^G(x,x,t,Q^2)$
$x = 10^{-3}$
$Q^2 = 4\ GeV^2$
$-t$ [GeV^2]

effective functional form at small x:

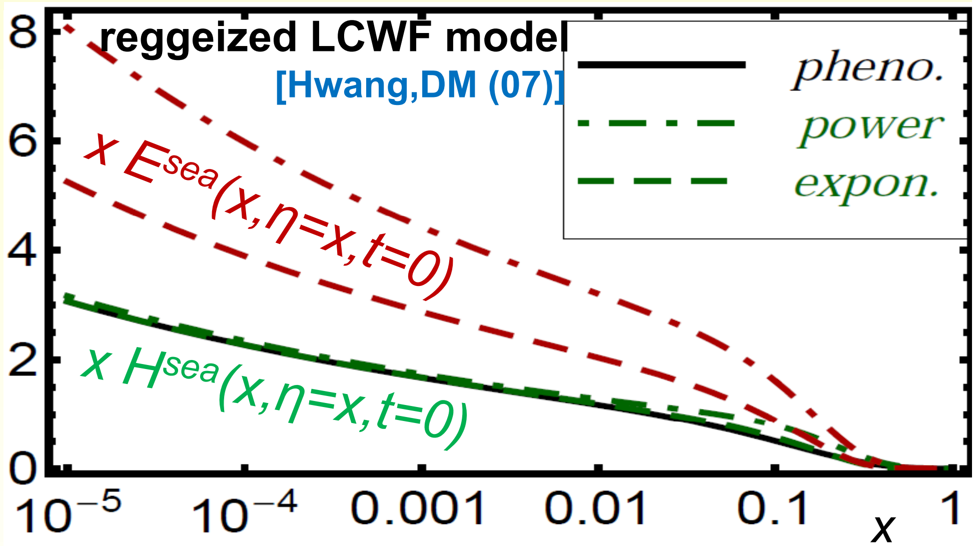
PDFs: $$q^{\text{sea}}(\xi,\mathcal{Q}) = n(\mathcal{Q})\xi^{-\alpha(\mathcal{Q})}, \quad \alpha \gtrsim 1, \quad F^{\text{sea}}(0)=1$$

GPDs: $$H = r(\eta/x=1,\mathcal{Q})F^{\text{sea}}(t)\xi^{\alpha'(t,\mathcal{Q})}q^{\text{sea}}(\xi,\mathcal{Q})$$

skewness

transverse distribution

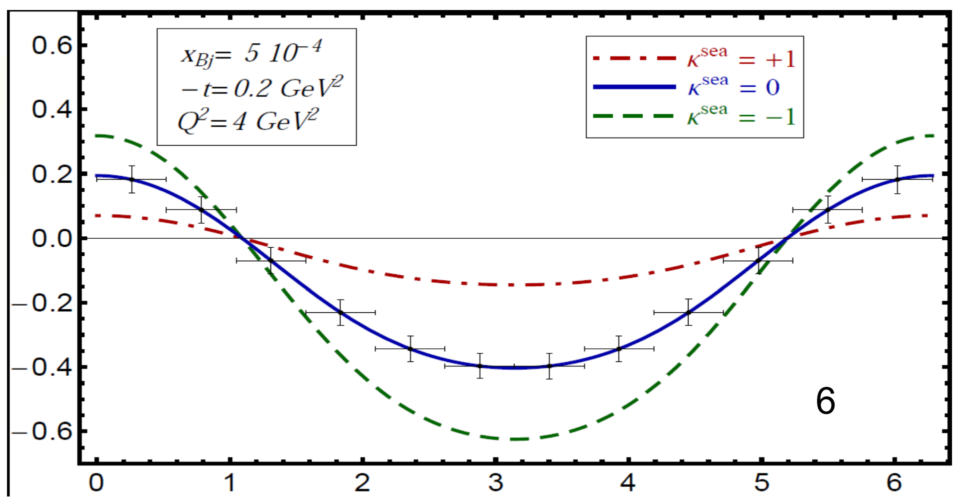
? $E(\xi,\xi,t,\mathcal{Q})$



- not seen in Regge phenomenology
- might be sizeable in instanton models
- reggeized spectator quark models
- pQCD suggests `pomeron' intercept
- large N_c states $E \sim H$ (isosinglet)

qualitative understanding of *E* is needed
(not only forJi`s spin sum rule)

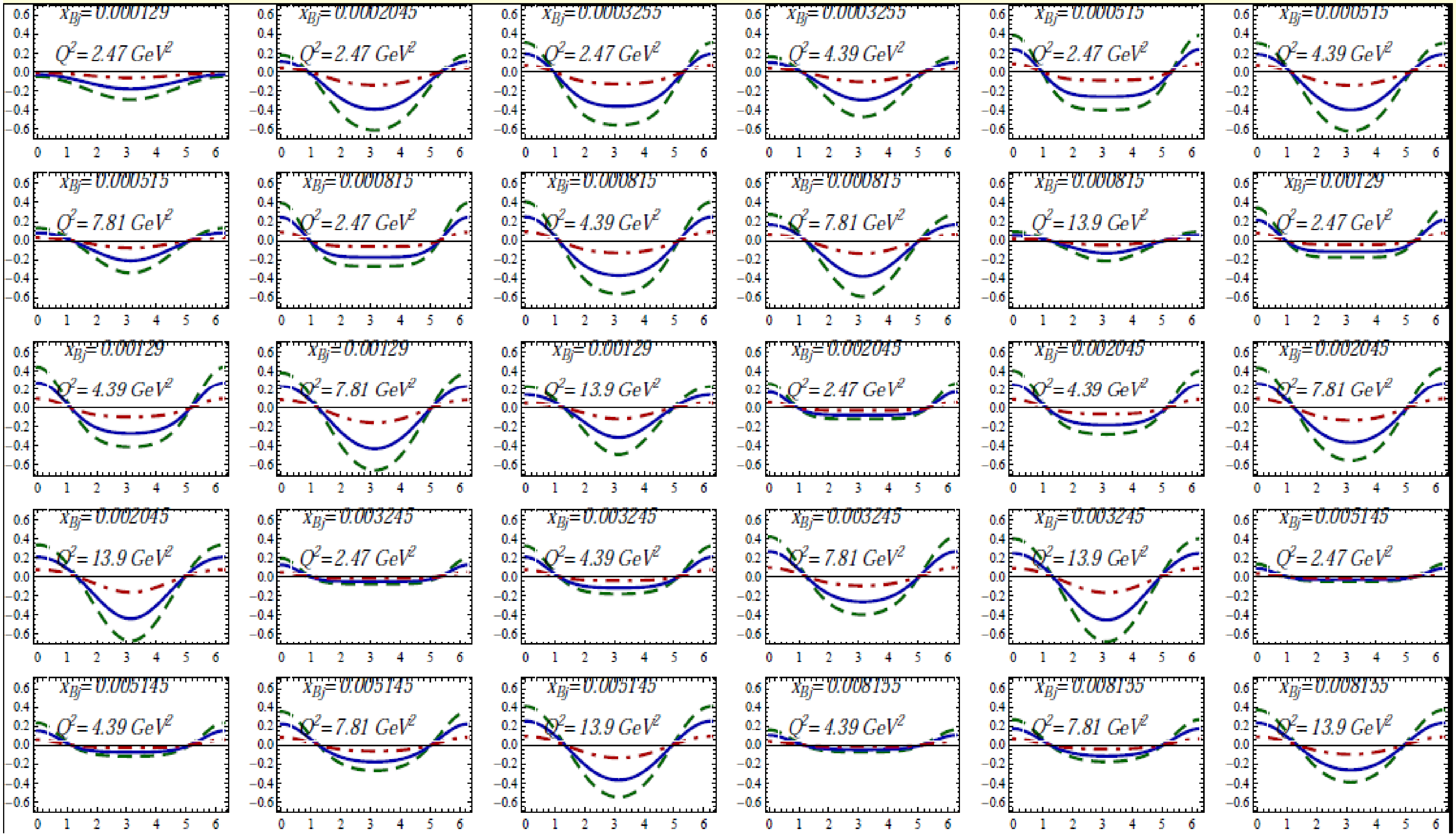
$$B = \int_0^1 dx\, xE(x,\eta,t,\mathcal{Q})$$



transverse target spin asymmetry
is **sensitive to *E* and sizeable at EIC**

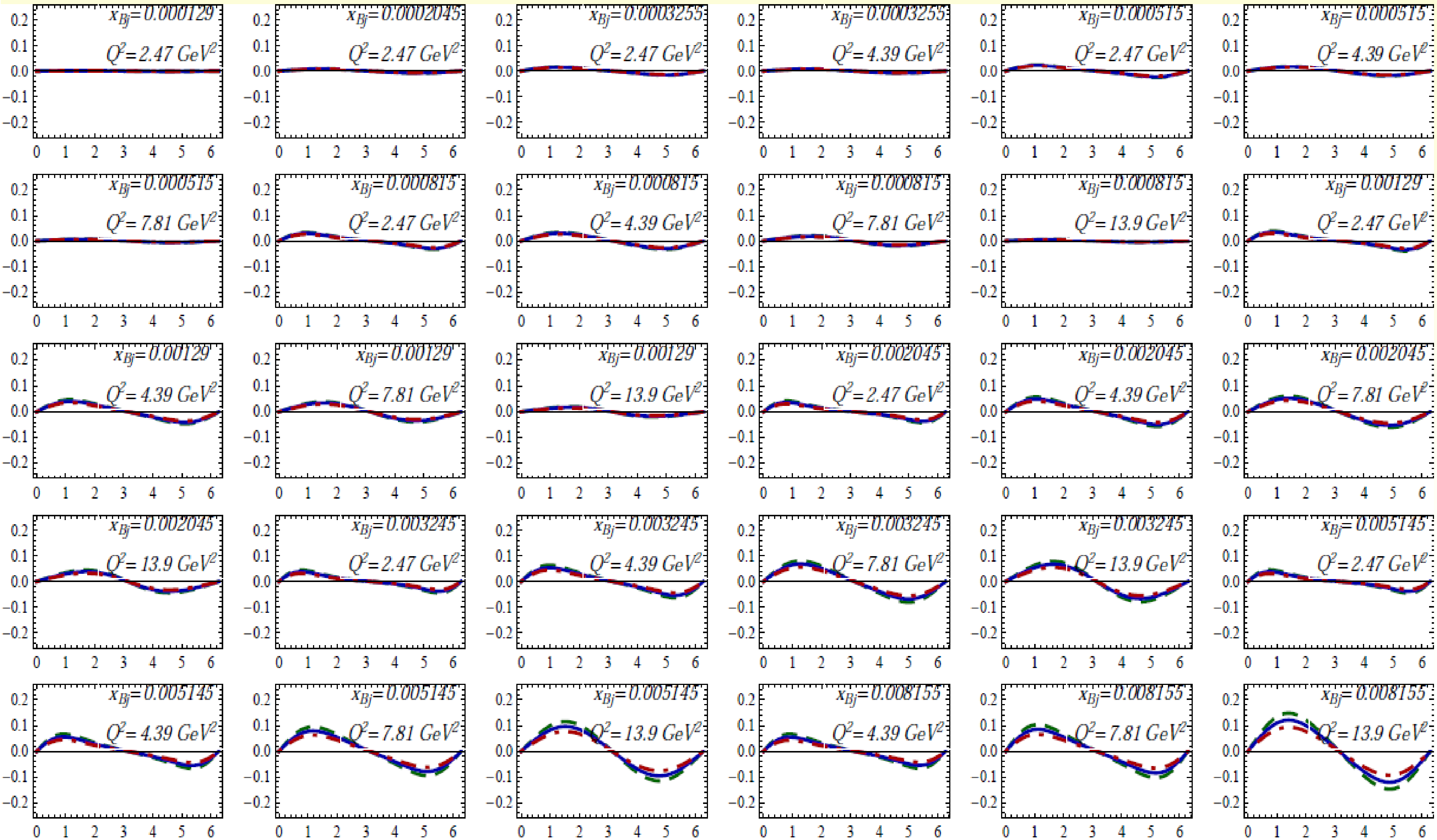
y-Transverse target spin asymmetry TSA

20x250 bins three models **E = 0** , **E= -H**, **E = +H,** sensitive to Im E



Longitudinal and x-transverse TSA

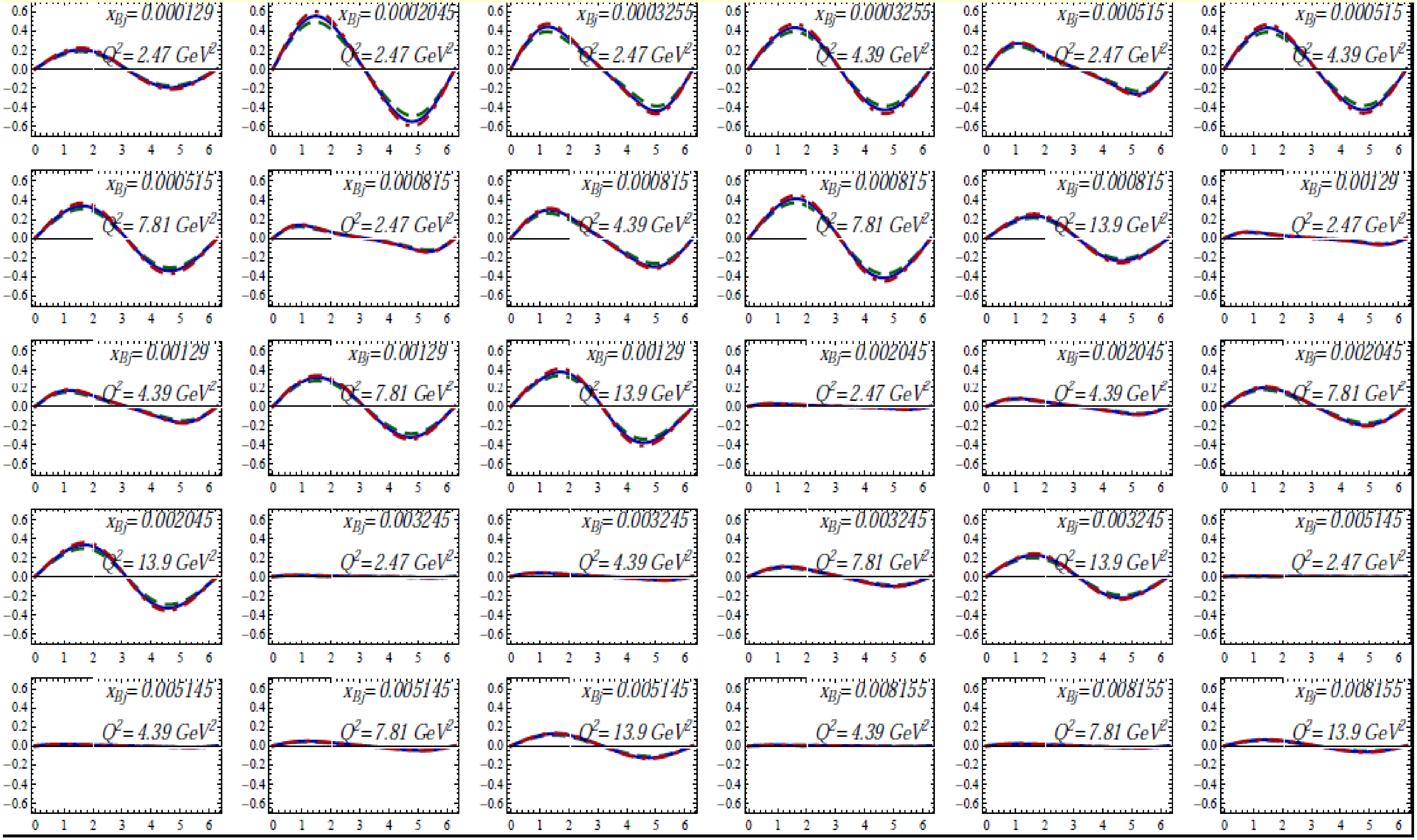
20x250 bins three models ***$\hat{H}$ = 0*** , ***$\hat{H}$= -H/2,*** ***$\hat{H}$= +H/2***, (in principle) sensitive to Im $\hat{H}$
non-zero values expected for larger x



Beam spin asymmetry BSA

20x250 bins three models ***E* = 0** , ***E*= -*H***, ***E* = +*H***

BSA requires large y values, not sensitive to E, however, to Im H



The first DVCS+DVMP fit to H1/ZEUS data

a global GPD fit to LO works surprisingly well $\chi^2/d.o.f. \sim 2$